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Effective Date: 12/31/10

00CD-0001
Revision 30

WIPP Mine Ventilation Plan

Cognizant Section: Mine Engineering

Approved by: Stan Patchet

WIPP Mine Ventilation Plan Change History			
Date	**Revision Number**	**ECO Number**	**Description of Change**
04/30/00	6	9548, Add 2	Additional description added to Working Face Ventilation section to differentiate between an advancing section and a retreating one. Operating limits set in the Safety Considerations section pertaining to the Spendrup 1120-70 fans uses on the working section. Appendix E added to provide auxiliary ventilation design information.
08/03/00	7	9548, Add 3	Minor Clarifications, update of Table 2 for Diesel Equipment, Revision of all system drawings to depict completion of Panel 2 and installation of all necessary ventilation control devices.
03/08/01	8	10028	Removal of 100-75-50 Rule and disallow excessive idling of Diesel Equipment in preparation of new ruling on Diesel Particulate Matter regulations under 30 CFR §57.5060 through §57.5075. Update operator information to reflect new WTS staff. Changes are highlighted
8/22/01	9	10238	Clarification as to the use of brattice cloth during the waste emplacement process in the Disposal Area. Minor changes to Table 2 for Diesel Equipment. Changes to project personnel.
12/10/01	10	10330	Removal of the 60 foot per minute rule. Changes to project personnel. Changes to requirements for use of ducting.
06/19/02	11	No ECO	Document reformatted and changes made. Document controlled in QMIS.
07/16/02	12	No ECO	Editorial change to add piece of equipment to Table 2, Underground Diesel equipment.
03/12/03	13	10692	Revision to underground diesel equipment list. Updates to 54-W-001-W and 54-Z-001-W drawings. Change Westinghouse to Washington. Add a reference. Minor editorial changes.
07/08/03	14	10756	Revision to airflow path, routing air through S-2180 instead of S-1600.
12/16/03	15	10836	Removal of U/G booster fans, bulkheads, and vent reversal mode per ECP-1-VU00-009.
01/14/04	16	10935	Correction to manufacturer name, Table 2.

WIPP Mine Ventilation Plan Change History			
Date	**Revision Number**	**ECO Number**	**Description of Change**
07/29/04	17	11069	Editorial change to page 1, page 15, and Table 2 and references on page 18. Replaced maps 54-W-001-W, 54-Z-001-W, and 54-W-013-W.
01/27/05	18	11198	Panel 3 has been added to the waste disposal ventilation circuit. This change was incorporated into the semiannual update of the MVP.
06/28/05	19	11319	Incorporate drawing revisions
01/11/06	20	11428	Incorporate drawing revisions, update references and Table 2.
05/10/06	21	11543	Complete rewrite, incorporate drawing revisions.
12/18/06	22	11687	Incorporate new diesel equipment to the equipment list and update the current and future mine footprint layouts.
07/18/07	23	11820	Updating drawings associated with the plan and updating the diesel equipment list.
09/14/07	24	11858	Correction to description of equipment 52-H-127, Table 2.
04/01/08	25	11992	Addition of Equipment in Table 2 and corrected Eng. Model number on 2 pieces of equipment.
12/17/08	26	12157 Add. 1	Addition of new diesel equipment and update current and planned maps of the U/G. Correct 74-U-129 cfm
06/10/09	27	12334	Remove 5 pieces of equipment and add in one new piece of equipment to Table 2 – Underground Diesel Equipment list.
12/17/09	28	12470	Updated to show current underground diesel equipment, a current mine map, and a map showing the projected mine layout in December 2010.
06/21/10	29	12600	Update to show current footprint and current diesel equipment.
12/31/10	30	12742	Updated drawings, no change to document text. Updated 54-W-001-W (Appendix A) and 54-Z-001-W (Appendix B) are available in the EFR.

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1.0 INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) was authorized by Congress (Department of Energy National Security and Military Applications of Nuclear Energy Act of 1980 [Public Law 96-164]) to provide "a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the United States exempted from regulation by the Nuclear Regulatory Commission."

To fulfill this mission, the U.S. Department of Energy (DOE) constructed a full-scale facility to demonstrate both technical and operational principles for the permanent isolation of transuranic waste. The WIPP disposal facility horizon, which includes construction (mining) and experimental and waste disposal areas, is located approximately 2,150 feet below the surface in the Salado Formation, a thick sequence of evaporites that are predominantly halite.

The WIPP underground ventilation system consists of three intake vertical shafts, interconnecting drifts and cross-cuts. Bulkheads, airlocks, and salt pillars separate the drifts. They are connected to an exhaust shaft that connects to the main surface fans.

2.0 PURPOSE STATEMENT

This plan satisfies the requirements for a mine ventilation plan as required by Title 30 Code of Federal Regulations (CFR) §57.8520, "Ventilation Plan," and the "New Mexico Safety Code for All Mines." It is based on current plans, conditions, and assumptions concerning the operation of WIPP. This document will be revised at least annually to reflect any ventilation system changes.

3.0 THE MINE NAME AND OPERATOR

Name:	Waste Isolation Pilot Plant
Address:	P.O. Box 2078 Carlsbad, NM 88221-2078
Telephone Number:	(575) 234-7200
Emergency Number:	(575) 234-8111
Name of Owner:	U.S. Department of Energy
Name of Operator:	Washington TRU Solutions LLC (WTS)

4.0 CURRENT MINE MAP

See Appendix A for a current mine map showing the following:

1) Direction and quantity of principal air flows.

2) Locations of seals used to isolate abandoned workings.

3) Locations of areas withdrawn from the ventilation system.

4) Locations of all main, booster and auxiliary fans not shown on the Typical Face Ventilation Drawings.

5) Locations of air regulators and stoppings and ventilation doors not shown on the Typical Face Ventilation Drawings.

6) Locations of overcasts, undercasts and other airway crossover devices not shown on the Typical Face Ventilation Drawings.

7) Locations of known oil or gas wells.

8) Locations of known underground mine openings adjacent to the mine.

9) Locations of permanent underground shops, diesel fuel storage depots, oil fuel storage depots, hoist rooms, compressors, battery charging stations and explosive storage facilities. Permanent facilities are defined in 30 CFR Part 57.8520 as those facilities intended to exist for one year or more.

5.0 ONE-YEAR PROJECTION MINE MAP

See Appendix B for a mine map showing significant changes in the ventilation system projected for one year.

6.0 MINE VENTILATION FANS

6.1 Mine Fans and Exhaust Filter Building (EFB) Fans

A total of six surface ventilation fans (e.g., three main fans and three filtration fans) supply airflow to the underground. The main fans are 700A, 700B, and 700C. The filtration fans are 860A, 860B, and 860C. They are located on the surface of the WIPP facility atop the Exhaust Shaft (ES), and are operated in various configurations to provide the necessary airflow to the underground. Table 1, Fan Specifications, lists the physical and operating data of these fans. The fan curves are located in Appendix C.

Table 1 - Fan Specifications

	MAIN VENTILATION FANS		EFB FANS
Equipment No.	41-B-700A 41-B-700B	41-B-700C	41-B860A 41-B860B 41-B860C
Manufacturer	Chicago Blower	TLT Babcock	Novenco
Model	D/1910A	14144AC/1665/0 CW (Rbr=117)	BC/542
Type	Centrifugal	Centrifugal	Centrifugal
Size (diameter - inches)	94.375	94.5	56 1/8
Speed (rpm*)	710	710	1180
Static Pressure (in. w.g.*)	12.5	9.65	13
Air Quantity (scfm*)	212,500	212,500	70400 (acfm*)
Efficiency (percent)	N/A	TBD	83.3
Blade Type	Airfoil	Airfoil	Airfoil
Motor HP	600	600	235
Voltage (v)	4160	4160	460
Inlet Vanes/range	Yes - 0-90 Deg.	Yes - 0-105	Yes - 0-90
Wheel Blade Setting	Fixed	Fixed	Fixed

* Abbreviations

rpm - revolutions per minute
in. w.g. - inches water gauge
scfm - standard cubit feet of air per minute
acfm - actual cubit feet of air per minute

6.2 Face Ventilation Fans

Diagrams showing the typical working face ventilation are found in Appendix D. One or two 100-HP Spendrup 1120-70 fans (in series as necessary) are used with ventilation ducting to exhaust the dead-end working faces. The fan curve and a fan pressure table are located in Appendix C.

7.0 NUMBER AND TYPE OF INTERNAL COMBUSTION ENGINES USED UNDERGROUND

Table 2 lists the internal combustion engines used underground, along with the make and model of the unit, type of engine, make and model of the engine, brake horsepower rating of the engine, and the approval number.

Table 2 - UNDERGROUND DIESEL EQUIPMENT

WIPP Equip #	Manufacturer	Description	Model	Eng. Model	HP	MSHA CFM	MSHA Cert #
52-H-005A	TAYLOR	FORKLIFT (41T)	TY-820L	F10L413FW	231	20,000	24/D92-0
52-H-007C	TOYOTA	FORKLIFT (6T)	5FD70	14Z	94	20,000	NONE
52-H-008A	GETMAN	CH TRANSPORTER	A-64	F5L413FW	128	10,000	24/D116-0
52-H-008B	GETMAN	CH TRANSPORTER	A-64	F5L413FW	128	10,000	24/D116-0
52-H-008C	GETMAN	CH TRANSPORTER	A-64	BF4M2012C	138	6,500	07-ENA04003
52-H-033	TOYOTA	FORKLIFT (6T)	5FD70	14Z	94	20,000	NONE
52-H-034	TOYOTA	FORKLIFT (6T)	7FDU70	12Z	89	7,500	TIER 2
52-H-125	TAYLOR	FORKLIFT (20T)	TYO-400S	F8L413FW	185	16,000	24/D92-0
52-H-126	TOYOTA	FORKLIFT (7.5T)	5FD70	12Z	94	20,000	NONE
52-H-127	TOYOTA	FORKLIFT	7FDU80	STALL 04.6137	80	15,000	NONE
74-G-089	IR	AIR COMPRESSOR	250 CFM	F5L912W	68	6,500	24/D115-0
74-G-147	IR	PORTABLE AIR COMPRESSOR	P260WIR/2005/A	41R18T	86	7,500	TIER 2
74-GE-001	YANMAR/ HITACHI	SANITATION TRAILER	L6O AE-DE	81L	10	2,500	NONE
74-H-014	PRIME MOVER	SKID STEER	L-1300	QVD	40	5,000	NONE
74-H-026	TOYOTA	FORKLIFT(4T)	02-5FD35	11Z	81	10,000	NONE
74-H-027	TOYOTA	FORKLIFT(4T)	02-5FD35	11Z	81	10,000	NONE
74-H-029	MELROE	SKID-STEER	753-C	V2203E	40	5,000	NONE
74-H-035	TOYOTA	FORKLIFT (4-T)	5FD35	13Z	89	7,500	TIER 2
74-H-036	TOYOTA	4-TON FORKLIFT	5FD35	13Z	89	7,500	TIER 2
74-H-039	GENIE	BOOM MAN LIFT	Z34-34/22IC	D-1105	23.5	2,500	TIER 2
74-PE-001	YANMAR	PORT. GEN	6121002	LA SERIES 40544	9	1,000	NONE
74-PE-003	YAMAHA	PORTABLE GENERATOR	EDL65005	ZB600-EGL	13.5	2,500	NONE
74-Q-012	KAWASAKI	AMBULANCE	2510	2510	24	3,000	NONE
74-Q-014	SCAT/I.E.S.	FIRE/RESCUE TRUCK	K-60B	F3L912W	34	4,000	24/D100-0
74-U-002-A	EIMCO	LHD	913	3304NA	110	10,700	24/D88-0
74-U-002-C	Sandvik EJC	LOADER LHD	145	N0635H32	190	12,000	7E-B080-0

Table 2 - UNDERGROUND DIESEL EQUIPMENT

WIPP Equip #	Manufacturer	Description	Model	Eng. Model	HP	MSHA CFM	MSHA Cert #
74-U-003	GETMAN	LUBE TRUCK	A-64	F6L912W	82	7,500	24/D102-0
74-U-004	GETMAN	LUBE TRUCK	A-64	BF4M2012C	138	6,500	07-ENA04003
74-U-006-A	EIMCO	HAUL TRUCK	985-T15	F8L413FW	185	16,000	24/D92-0
74-U-006-B	EIMCO	HAUL TRUCK	985-T15	F8L413FW	185	16,000	24/D92-0
74-U-008	GETMAN	SCISSOR LIFT	A-64	F6L912W	82	7,500	24/D102-0
74-U-020	KUBOTA	TRACTOR	L-245	DH1101-A	25	2,000	24/D108-0
74-U-021	KUBOTA	TRACTOR	L-245	DH1101-A	25	2,000	24/D108-0
74-U-023	KUBOTA	TRACTOR	L-245DT	DH1101-A	25	2,000	24/D108-0
74-U-024	KUBOTA	TRACTOR	L-245DT	DH1101-A	25	2,000	24/D108-0
74-U-039	EIMCO	LHD	913	F6L413FW	139	12,000	24/D92-0
74-U-040	BOBCAT	SKID STEER LOADER	17S160	V2003M-DI-T	56	3,500	TIER 2 EPA
74-U-111	ATLAS COPCO	BOLTER	H-226D	F6L912W	82	7,500	24/D102-0
74-U-114	GETMAN	SCISSOR LIFT	A-64	F6L912W	82	7,500	24/D102-0
74-U-115	FLETCHER	SCALER	SV-4D	F6L912W	82	7,500	24/D102-0
74-U-116	JLG	MANLIFT	34HA	F2L1101	28	2,500	24/D107-0
74-U-117	EIMCO	LHD	EJC-130	3304PCT	165	33,000	24/D54-56
74-U-121	ALPINE	FLOOR PLANER	100-CT	64Z20298C	230	29,000	24/D150-0
74-U-123	ATLAS COPCO	CRAWLER DRILL	264-DC	F3L1011F	44	2,500	7E-13014-0
74-U-127	FLETCHER	SEAL CUTTER	5V-40	D-BF6MI0 13CP	255	12,000	7E-B007-0
74-U-128	FLETCHER	ROOF BOLTER	3024AD	9SB3.9	120	6,500	TIER 2
74-U-129	GETMAN	HAUL TRUCK	1248	OM904LA	174	7,500	7E-B098
74-U-130	GETMAN	HAUL TRUCK	1248	OM904LA	174	7,500	7E-B098
74-U-131	FLETCHER	ROOF BOLTER	3124AD	QSB 4.5	130	6,500	TIER 2
74-U-132	KUBOTA	UTILITY TRACTOR	L4240 HST	V2203	42	3,000	TIER 2
74-U-133	KUBOTA	UTILITY TRACTOR	L4240 HST	V2203	42	3,000	TIER 2
74-U-137	FLETCHER	ROOF BOLTER	3020N-AD	QSB-4.5	130	6,500	TIER 3
74-U-138	SANDVIK	4 YD. LHD	LH307	OM906LA	201	7,500	7E-B083
74-U-603	SIMMONS	BOOM LIFT TRUCK	32/216	F2L1011	28	5,000	24/D141-0
74-U-606	GETMAN	SCISSOR LIFT	A-64	OM904LA	174	7,500	7E-B098
74-UE-042	GETMAN	HAUL TRUCK	1248-13	F6L413FW	139	12,000	24/D92-0
74-UE-043	GETMAN	HAUL TRUCK	1248-13	F6L413FW	139	12,000	24/D92-0
74-UE-045	GETMAN	HAUL TRUCK	1248-13	OM904LA	174	7,500	7E-B098
74-UE-060	GETMAN	CRANE TRUCK	A-64	F6L912W	82	7,500	24/D102-0
74-UE-067	NEVADA	GENERATOR	NGSDZM190	BF12L413PW	316	50,000	24/D120-0
74-W-009	MILLER	WELDER	250	D622	16.5	2,000	TIER 2
74-W-011	MILLER BOBCAT	WELDER/ GENERATOR	250 DIESEL	D722	16.5	3,600	TIER 2

Table 2 - UNDERGROUND DIESEL EQUIPMENT

WIPP Equip #	Manufacturer	Description	Model	Eng. Model	HP	MSHA CFM	MSHA Cert #
74-W-012	KUBOTA	GENERATOR	GL 7000	Z482-EBG	10.9	1,500	TIER 4
74-W-013	LINE POWER	GENERATOR	300KWGEN	CURSOR 13TE3X	371	20,000	TIER 3
74-W-014	WACKER	TAMPING MACHINE	VP2050Y	L48V6-VWK	4.4	1,000	TIER II
75-H-031	SIMON	MANLIFT	32/21G	F2L1011	28	1,500	7E-B062-0

8.0 VENTILATION SYSTEM DESCRIPTION

The WIPP underground ventilation system consists of three vertical intake shafts, interconnecting drifts and cross-cuts. Bulkheads, airlocks, and salt pillars separate the drifts. They are connected to a common exhaust, which connects to the main surface fans. Figure 1, WIPP In Perspective, shows the relationship between the surface, shafts, and the underground repository. The airflow patterns and ventilation control devices are shown on Appendix A, Drawing No. 54-W-001-W (current revision). The four shafts are:

- Air Intake Shaft (AIS)
- Salt handling Shaft (SHS)
- Waste Shaft (WS)
- Exhaust Shaft (ES)

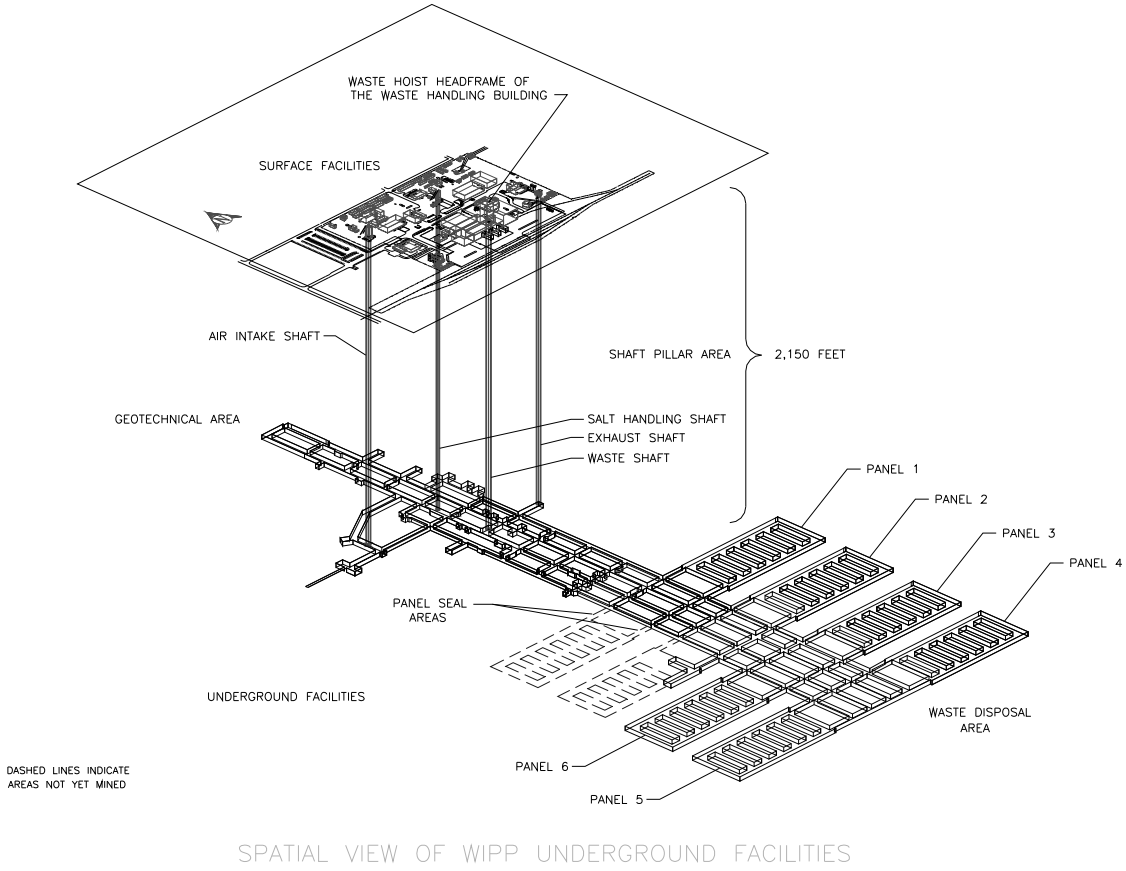


Figure 1, WIPP in Perspective

8.1 Ventilation System Description and Configurations

The three intake shafts supply air to the repository level, consisting of four separate air splits, and it is discharged through a common exhaust shaft. Fresh air entering the repository from the AIS is split in E0 to the north and south. The north air split is used to ventilate the North Area, which includes materials storage, an experimental area, and the underground diesel maintenance shop.

The south air split merges with the air from the SH shaft and travels south through the W30 entry. At S1000 this air is split into two ventilation circuits, the Waste Disposal Circuit and the Construction (mining) Circuit. The air split that goes to E140 (Waste Disposal Circuit) is used to ventilate the Waste Disposal areas.

The air split that stays in W30 is used to ventilate the Construction Circuit (mining) and may be exhausted through either W170 or E300, depending on operational needs.

Air entering through the WS is used to ventilate the WS and the Waste Shaft Station. This air is routed directly to the ES.

8.2 Modes of Operation

8.2.1 Normal Modes of Operation

The WIPP facility has five different fan usage configurations, modes of operation that can be set to supply variable quantities of air to the underground for normal day-to-day operation. The mode of operation is determined by the operational needs of the facility. The five modes are:

Normal Ventilation: Two of the three main 700 exhaust fans operating provide approximately 425,000 scfm unfiltered.

Alternative Ventilation: One of the three main 700 exhaust fans operating provides approximately 260,000 scfm unfiltered.

Maintenance Ventilation: One or two 700 exhaust fan(s) and one or two 860 filtration fan(s) operate in parallel.

Reduced Ventilation: Two 860 filtration fans, operating as unfiltered, provide 60,000 scfm each.

Minimum Ventilation: One 860 filtration fan, operating as unfiltered, provides 60,000 scfm.

8.2.2 Off-Normal Mode of Operation

WIPP has the following mode of operation to deal with "off-normal" conditions, such as a radioactive release:

Filtration Mode: One 860 filtration fan operating in conjunction with a High Efficiency Particulate Air (HEPA) filtration system located in the Exhaust Filter Building. Filtration mode is initiated either automatically (after the system detects a radioactive release) or manually through the Central Monitoring Room (CMR). The main fans and bypass plenum to the 860 fans are isolated. Two HEPA filters at 100 percent capacity each work with one 860 fan to provide 60,000 scfm in this mode.

8.3 Additional Ventilation Control Features

8.3.1 Shaft Isolation Doors

The Salt Shaft, Waste Shaft and Air Intake Shaft are equipped with fire isolation doors. These doors may be closed as a means of controlling the spread of fire, smoke, or toxic gases.

8.3.2 Diesel Generator Operation

In the event of either a total or isolated power loss to WIPP which affects the main or filtration fans, WIPP is equipped with two backup diesel generators. One of these generators may be brought on-line within approximately 30 minutes of a power failure to provide minimum ventilation to the underground.

9.0 REFERENCES

Public Law 96-164, Department of Energy National Security and Military Applications of Nuclear Energy Act of 1980

Title 30 CFR Part 57, "Safety and Health Standards Underground Metal and Nonmetal Mines"

WIPP System Design Description, VU00 Underground Ventilation (current revision)

New Mexico Mine Safety Code for All Mines

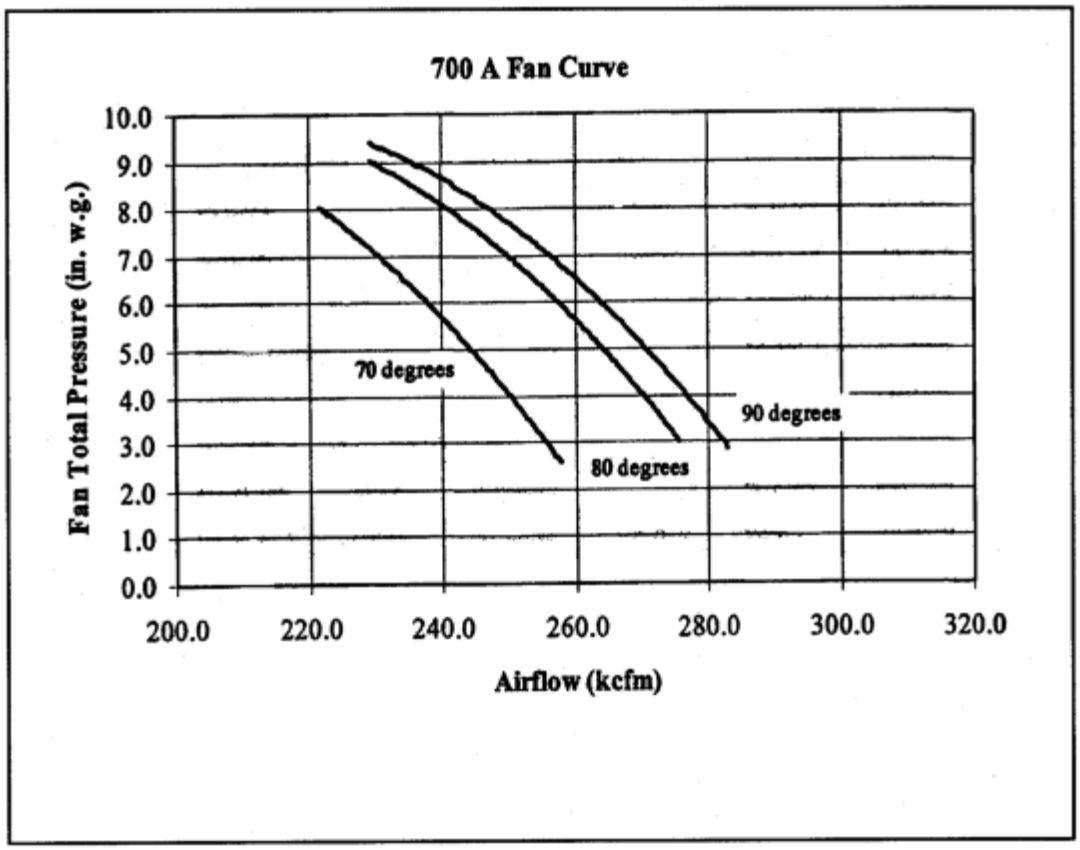
Appendix A – Drawing of Current Underground Mine Ventilation System (Drawing No. 54-W-001-W)

This drawing is available in the Engineering File Room

Appendix B – Drawing of Proposed Changes to Underground Ventilation System (Drawing No. 54-Z-001-W)

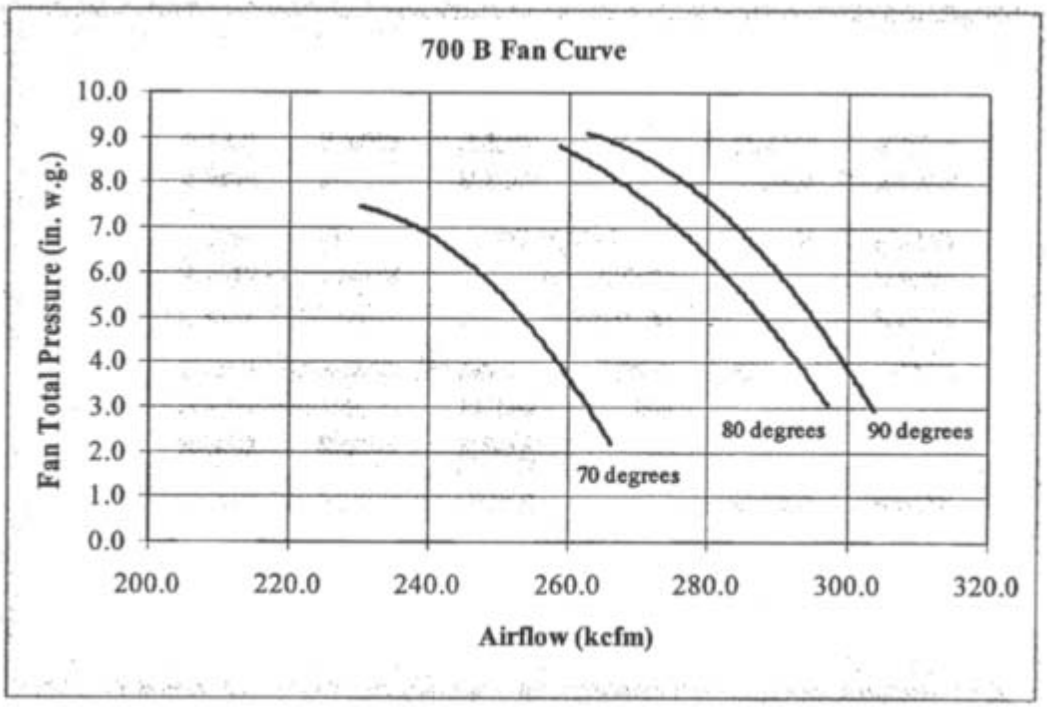
This drawing is available in the Engineering File Room.

Appendix C – Fan Curves



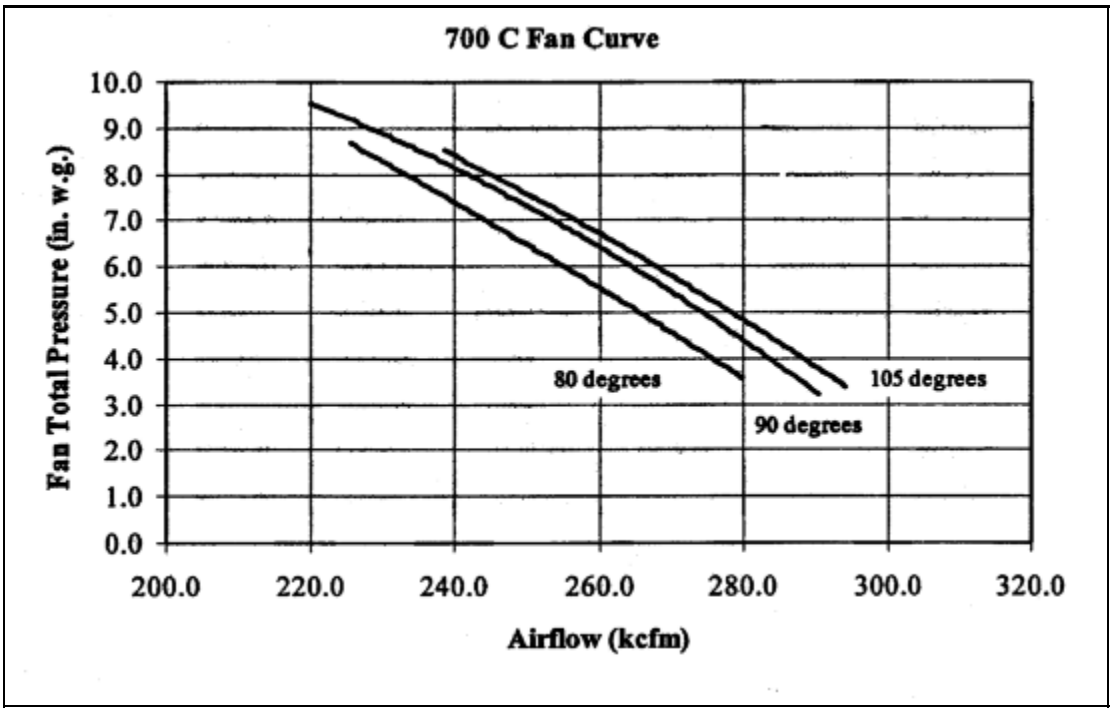
Fan 700A

Appendix C – Fan Curves (continued)



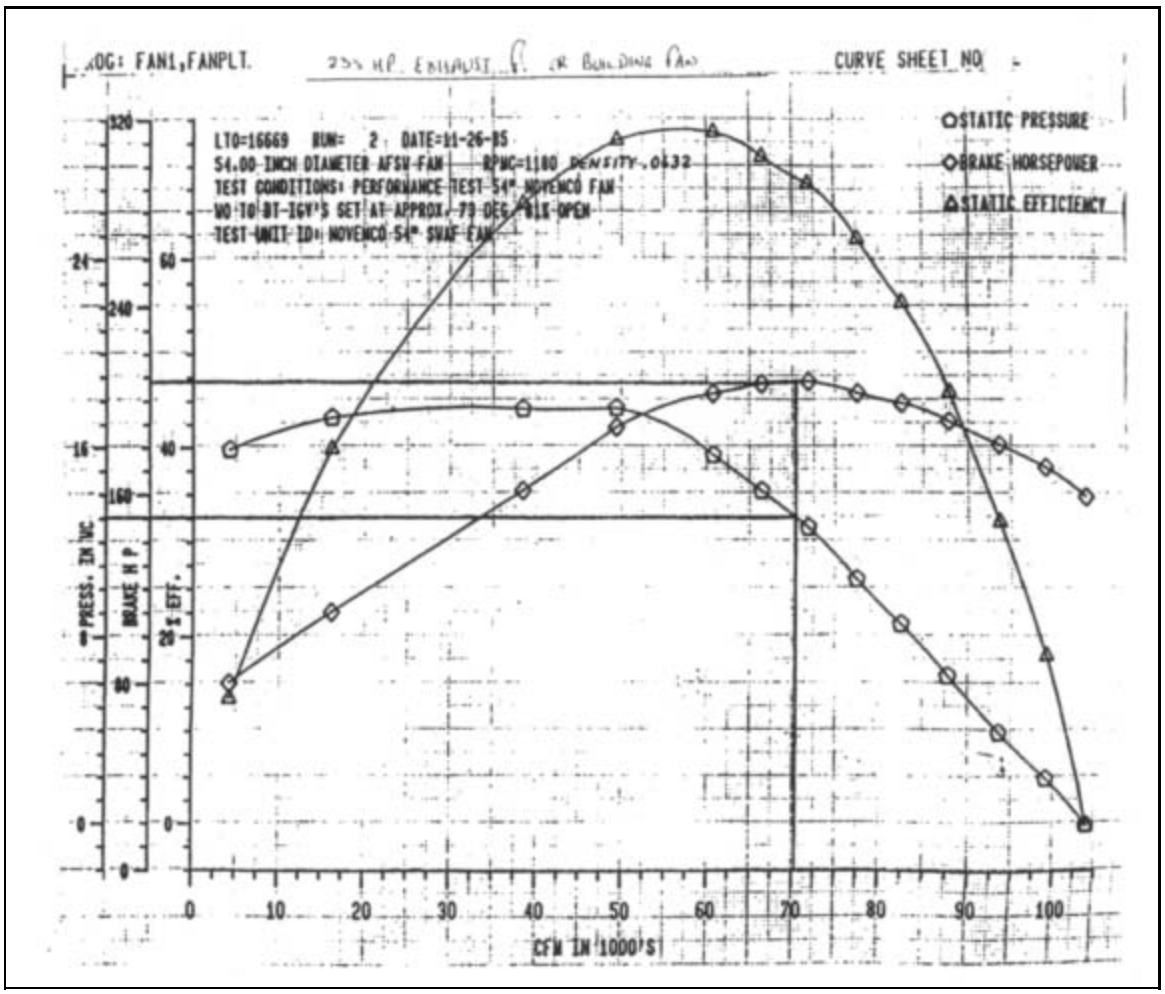
Fan 700B

Appendix C – Fan Curves (continued)



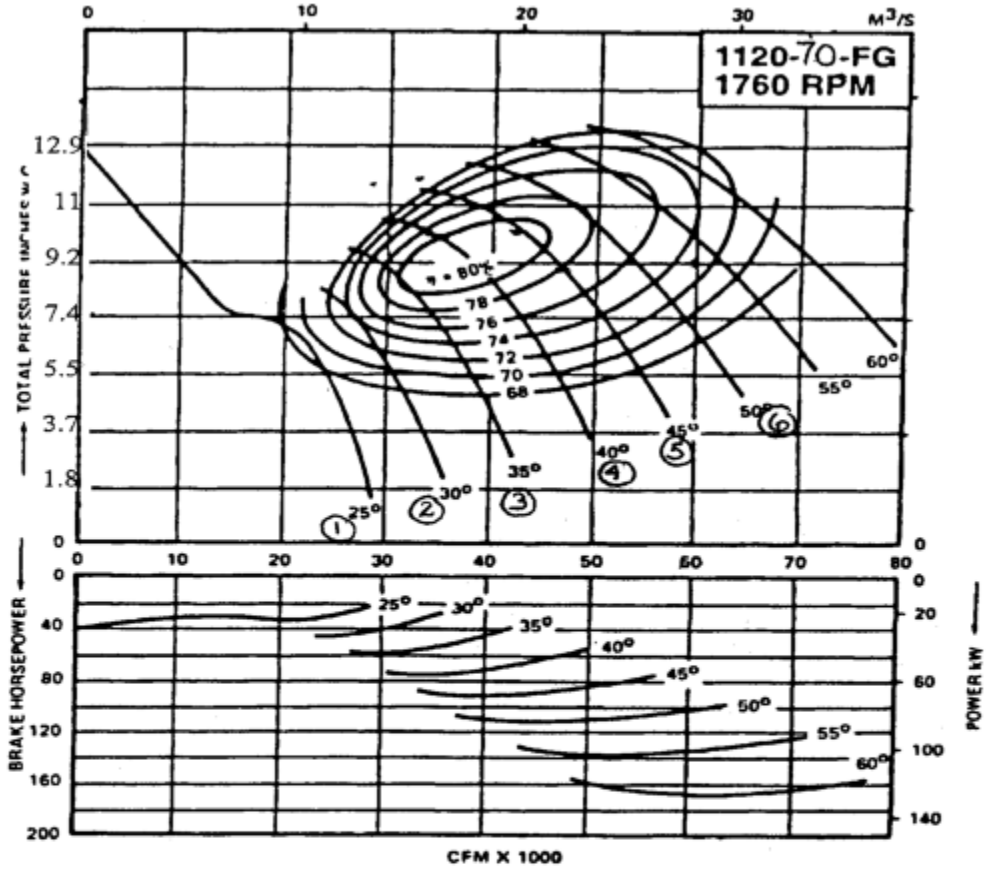
Fan 700C

Appendix C – Fan Curves (continued)



Filtration Fan(s) Curve

Appendix C – Fan Curves (continued)



- BLADE SETTING

PERFORMANCE AT DENSITY OF 0.069 LB./FT.³

SPENDRUP FAN CO.

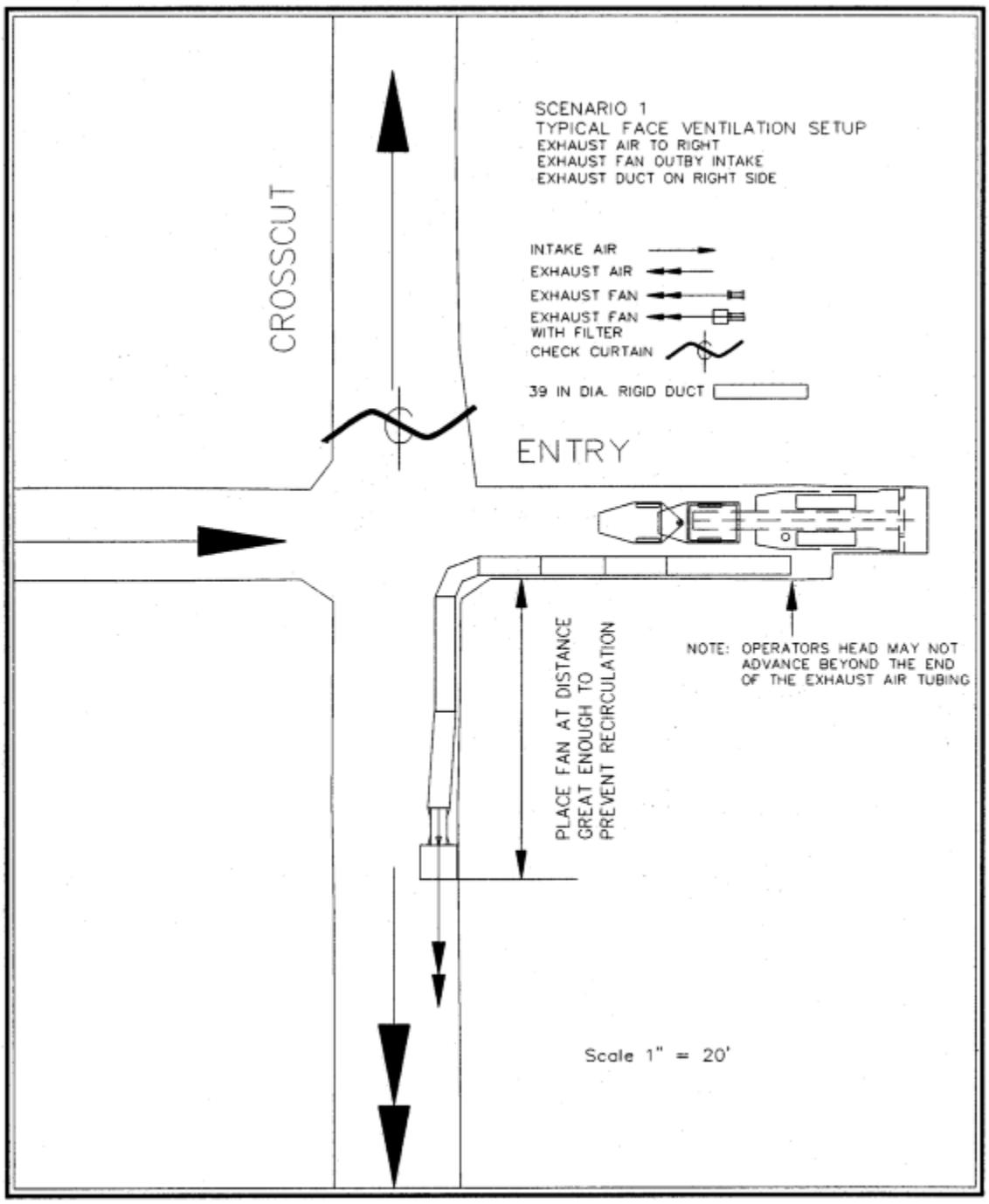
Auxiliary Mine Fan for Mining: Spendrup Model 1120-70

Appendix C – Fan Curves (continued)

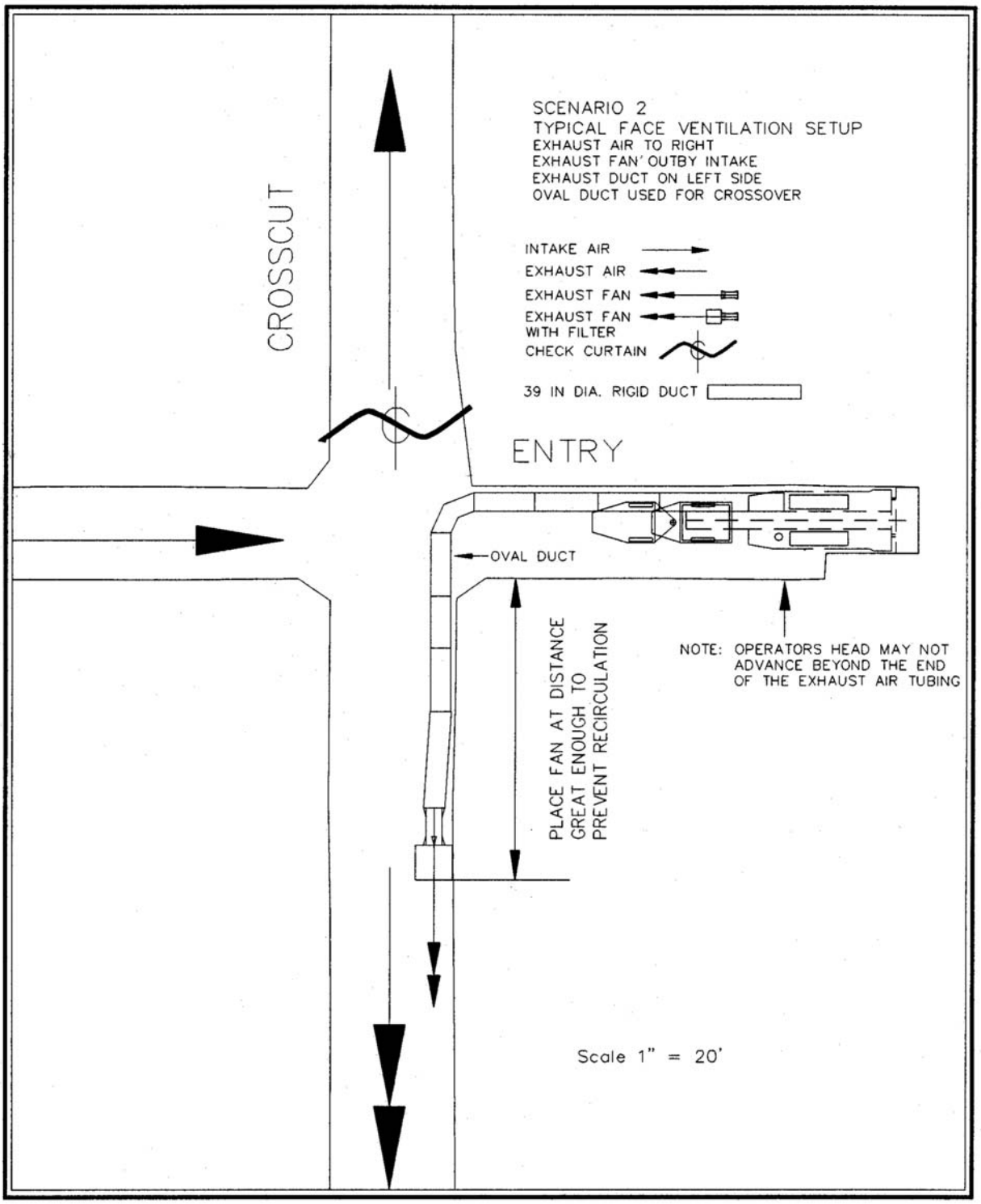
Fan Pressures for a Spendrup 1120-70 FG							
Quantity	Velocity Pressure	Blade Setting 3		Blade Setting 4		Blade Setting 5	
Q (cfm)	H_V (in W.G.)	H_T	H_S	H_T	H_S	H_T	H_S
20000	0.22	Undef.	Undef.	Undef.	Undef.	Undef.	Undef.
25000	0.35	Undef.	Undef.	Undef.	Undef.	Undef.	Undef.
30000	0.50	9.0 ***	8.50	10.55	10.05	Undef.	Undef.
35000	0.68	7.00	6.32	10.0 ***	9.32	11.48	10.80
39000	0.84	4.96	4.12	9.1	9.16	11.0 ***	10.16
40000	0.89	4.46	3.57	8.66	7.77	10.73	9.84
45000	1.12	Undef.	Undef.	6.04	4.92	9.65	8.53
50000	1.39	Undef.	Undef.	3.5	2.11	7.76	6.37
55000	1.68	Undef.	Undef.	Undef.	Undef.	5.40	3.72
58000	1.87	Undef.	Undef.	Undef.	Undef.	4.15	2.28

***** Do not exceed these Total Pressure values.**

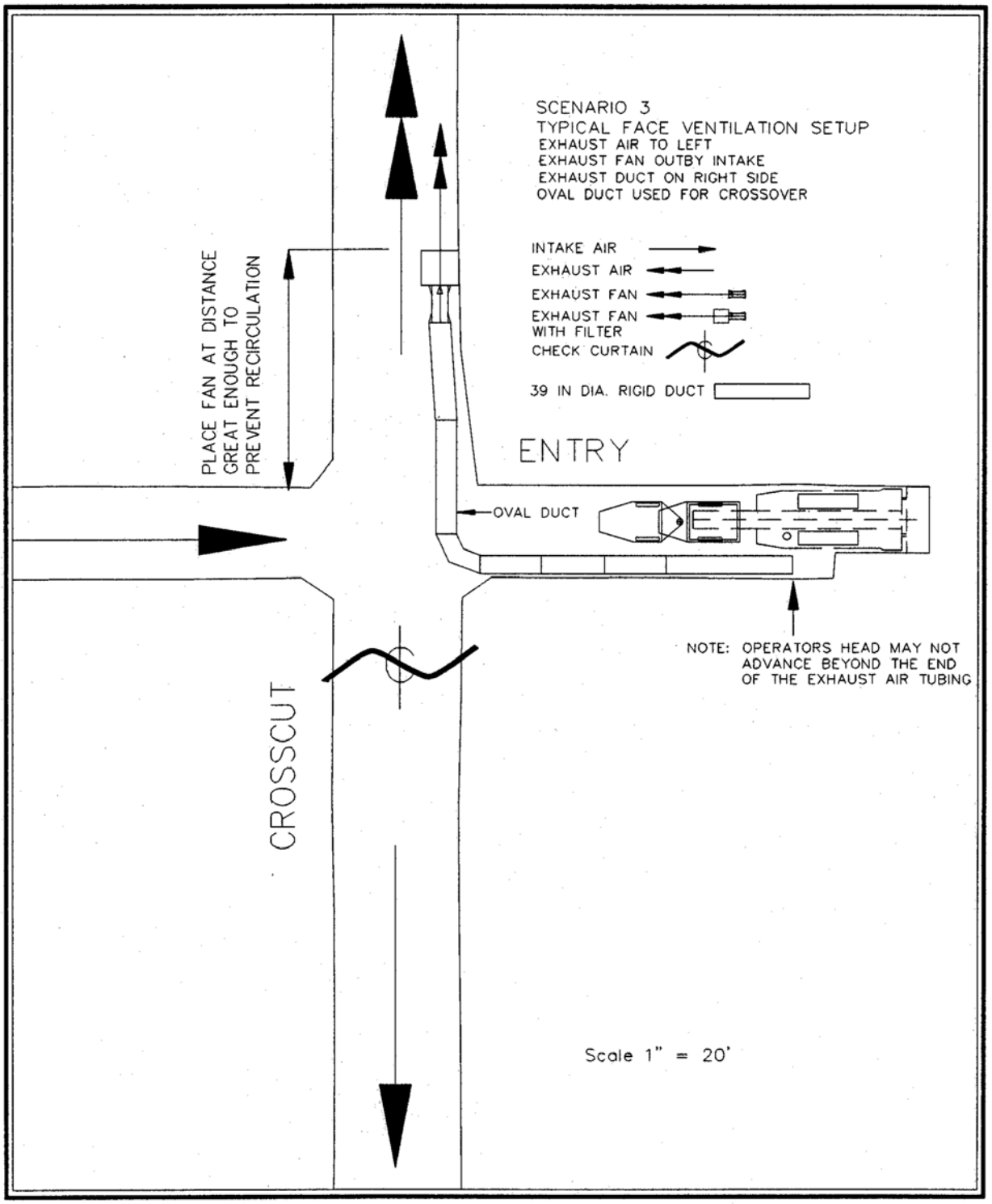
Appendix D – Typical Face Ventilation Scenarios



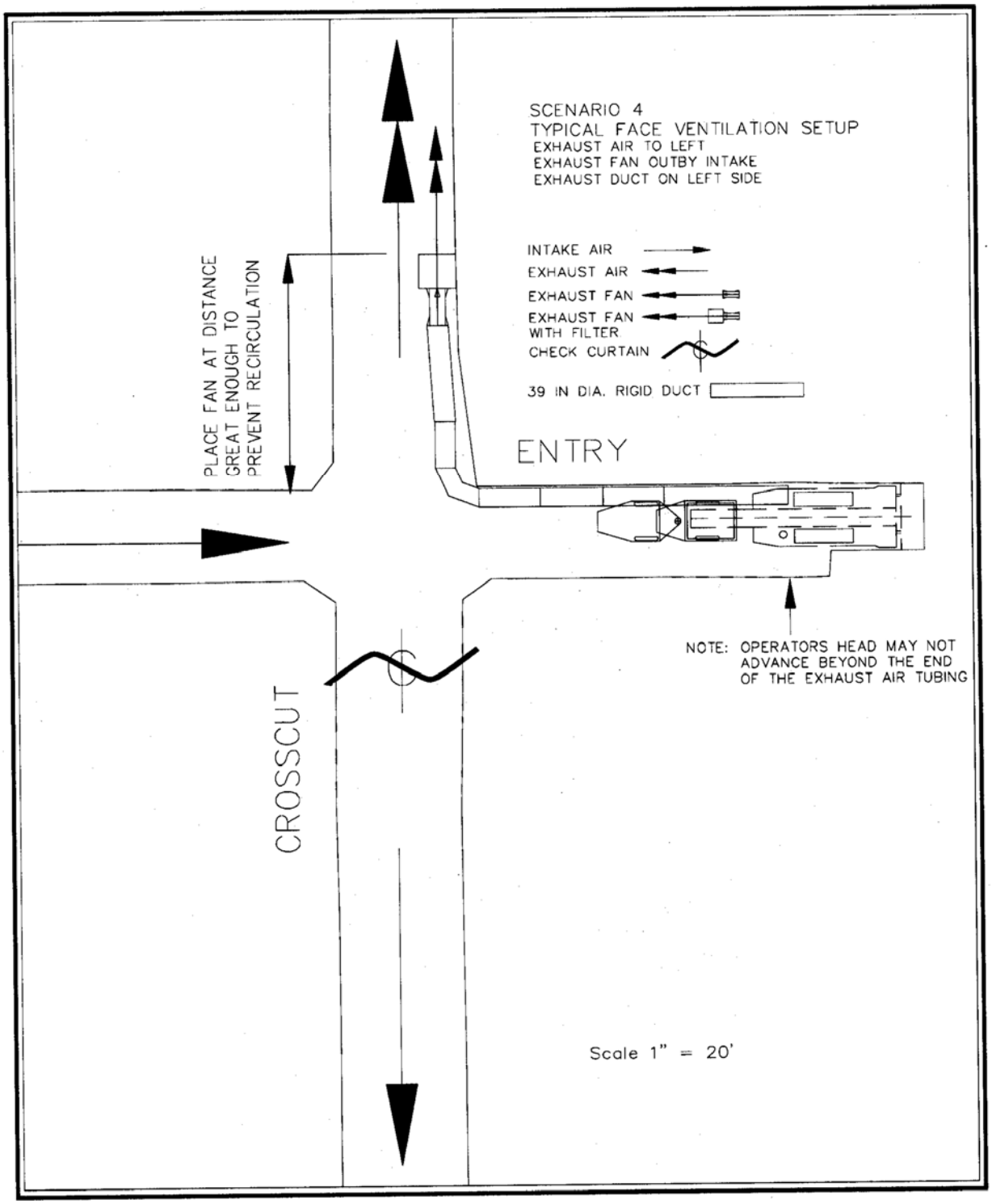
Appendix D – Typical Face Ventilation Scenarios (continued)



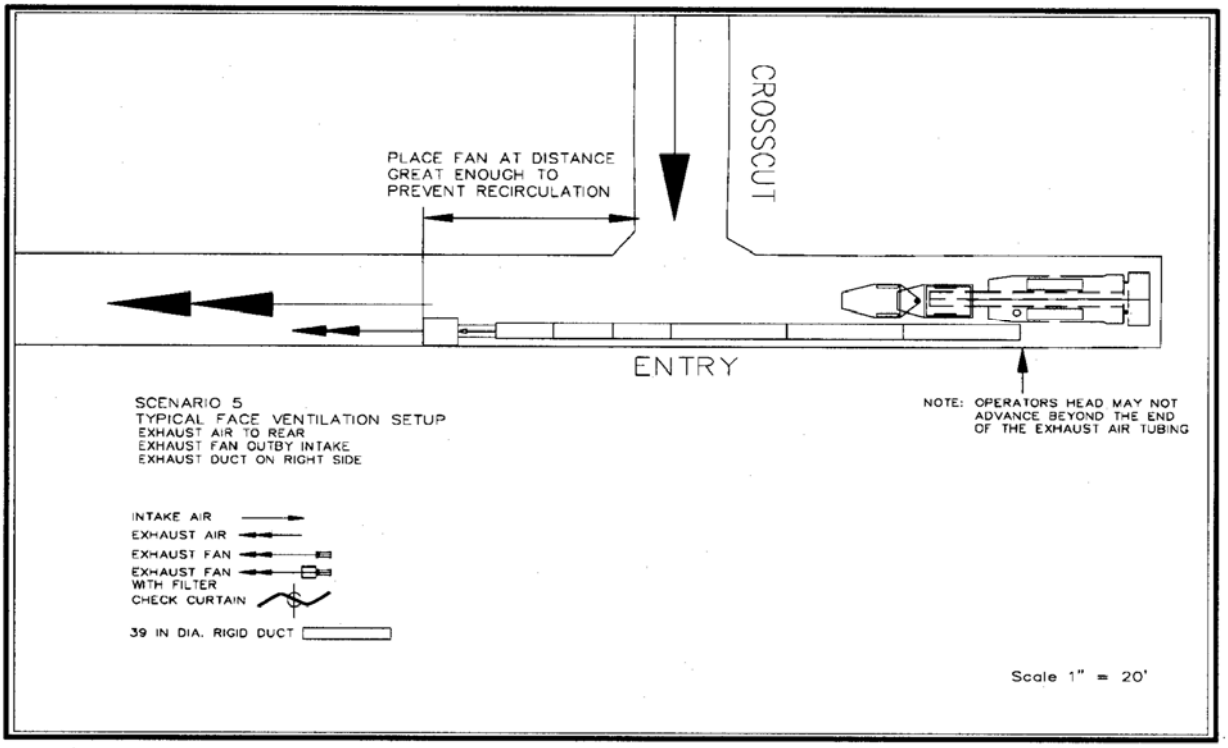
Appendix D – Typical Face Ventilation Scenarios (continued)

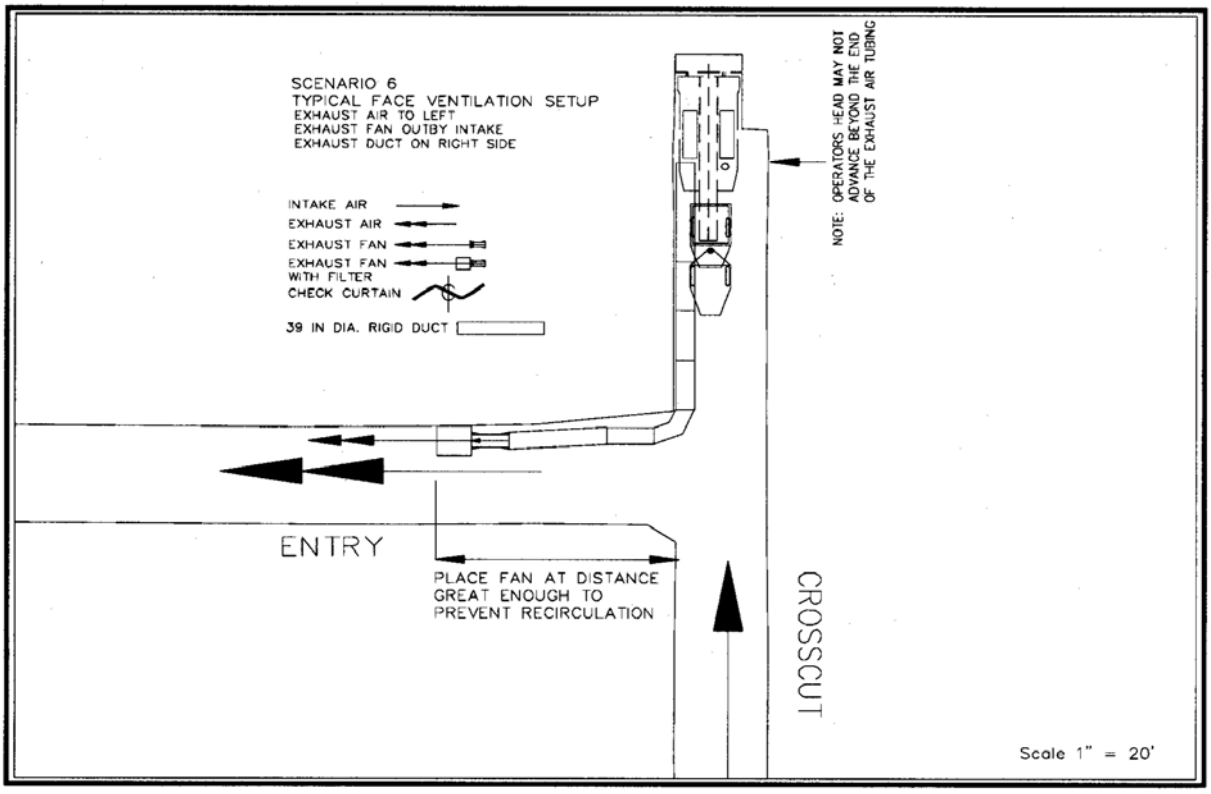


Appendix D – Typical Face Ventilation Scenarios (continued)

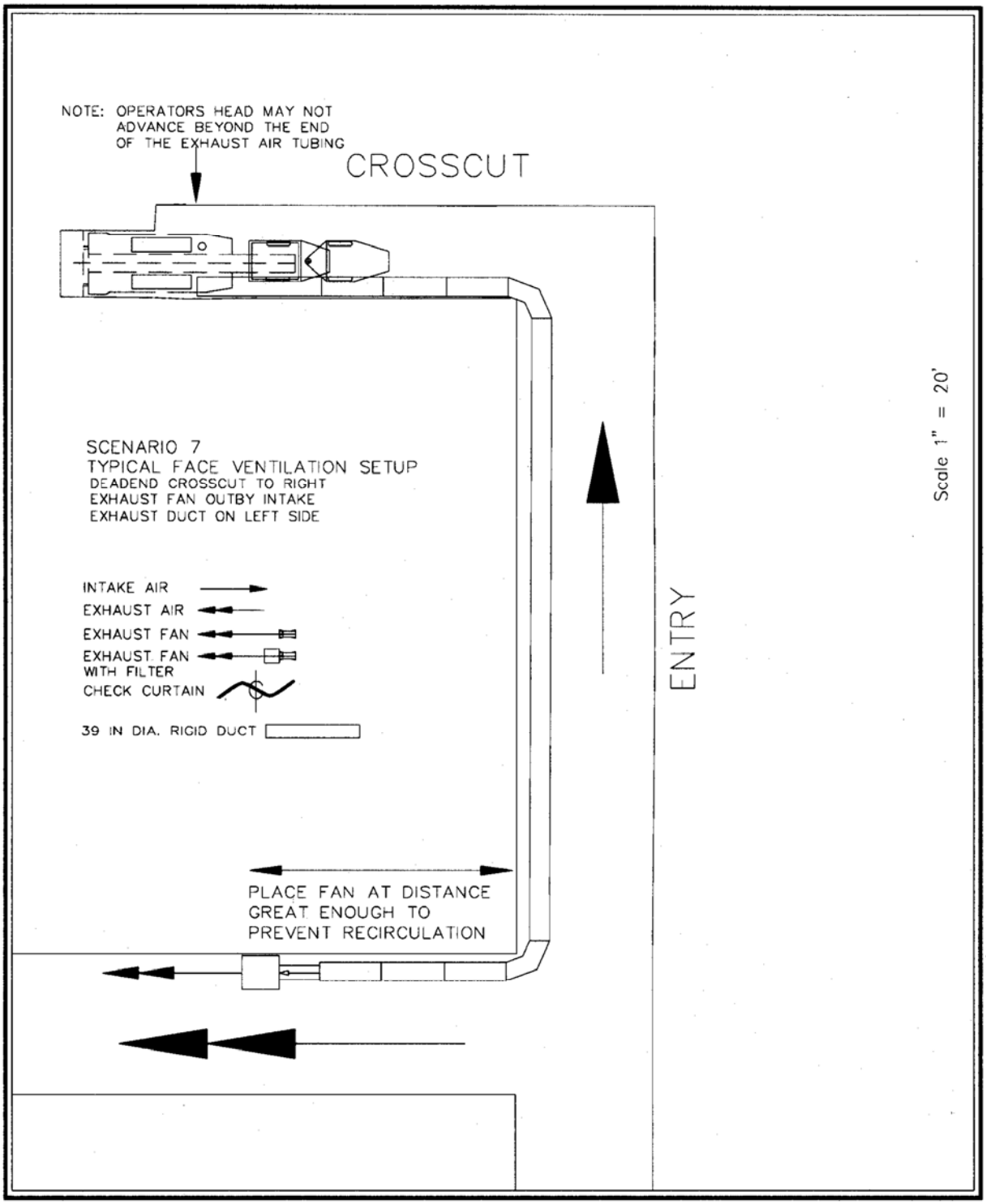


Appendix D – Typical Face Ventilation Scenarios (continued)





Appendix D – Typical Face Ventilation Scenarios (continued)



Appendix E – Auxiliary Ventilation System Design/Installation Considerations

Calculating Losses

Dynamic Losses

The pressure loss in each fitting, inlet and outlet must be calculated separately and is based on the velocity pressure of air at that point in the system.

Velocity pressure $Pv = \left(\frac{V}{4005} \right)^2$

$$\Delta H = C \left(\frac{V}{4005} \right)^2 \left(\frac{\rho}{.075} \right)$$

Friction Losses

Friction loss curves, which are provided in this brochure, are designed to give the pressure loss due to friction in the duct. The curves are based on the following formula:

$$\Delta H = \left(\frac{K L O Q^2}{5.2 A^3} \right) \left(\frac{\rho}{.075} \right)$$

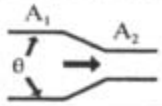
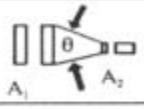
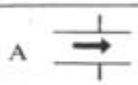
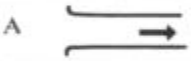
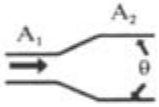
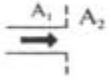
For all equations, the definitions are:

ΔH = pressure loss in in. w.g.
C = loss coefficient
V = air velocity in feet/minute
L = length in feet
O = perimeter in feet
Q = air quantity in 100,000 cfm
(60,000 cfm would be .60)
ρ = air density (.075 for standard air) in lb/ft^3

A = area of duct in square feet
K = the friction factor for the material
(Fiberglass duct is 11.7;
Steel duct is 12;
Cassette duct is 15;
Lay flat duct is 18;
Flexible suction duct is 27)

Appendix E – Auxiliary Ventilation System Design/Installation Considerations (cont.)

Loss coefficients for area changes

Type	Illustration	Conditions	Loss Coefficient
Gradual Contraction		θ	C_2
		30° 45° 60°	0.02 0.04 0.07
Equal Area Transformation		$A_1 = A_2$ θ ≤ 14°	C 0.15
Flanged Entrance		A = ∞	C 0.34
Duct Entrance		A = ∞	C 0.85
Formed Entrance		A = ∞	C 0.03
Gradual Expansion		θ	C_1
		5° 7° 10° 20° 30° 40°	0.17 0.22 0.28 0.45 0.59 0.73
Abrupt Exit		$A_2 = \infty$ $A_1/A_2 = 0.0$	1.00

Note: A "C" with a subscript indicates the cross-section at which velocity is calculated.

Loss coefficients for elbows

Type	Illustration	Conditions		
N°		Rectangular or round, with or without vanes	(N/90) times value for similar 90° elbow	
90° Round Section		Miter	1.30	65
		R/D = 0.5	0.90	
		0.75	0.45	23
		1.0	0.33	17
		1.5	0.24	12
		2.0	0.19	10

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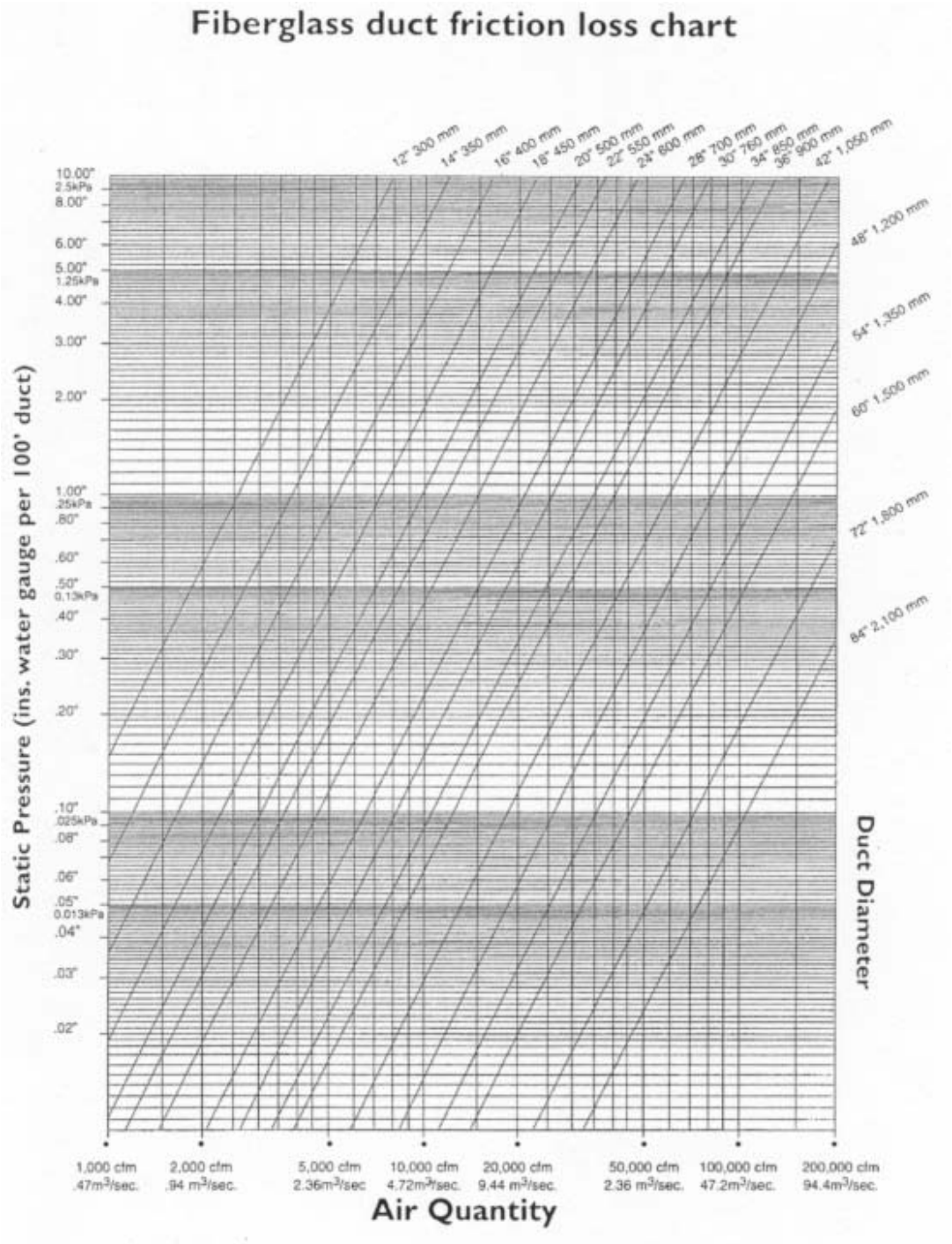
Appendix E – Auxiliary Ventilation System Design/Installation Considerations (cont.)



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